The Canadian Entomologist.

LXXIX APRIL, 1947 No. 4

REVEREND FATHER LEOPOLD, O.C.R., D.S.A. (1884-1947)

The Reverend Father Leopold, of the Oka Agricultural Institute, died suddenly on January 30, 1947, in his sixty-fourth year. At the time of his death, he was Director of External Relations of the Institute.

He was born at Nassau, British West Indies, on January 15, 1884, the son of Enrique Ortiz y Pi, a Spanish consular official, and Ada R. Black. He began his studies at the Sulpician College, Montreal, and he studied philosophy and theology at the Monastery of La Trappe, near Montreal, which he entered in 1902. He was ordained to the priesthood on May 24, 1907. Later, he studied horticulture in France, at Versailles and Angers.

Father Leopold served the Oka Agricultural Institute, and horticulture and plant-protection, long and well. He taught plant-protection at Oka and was Professor of Horticulture there from 1912 to 1946. In 1920 and 1928, respectively, he became Director of the faculties of agriculture and of veterinary science, positions which he held until 1938, when he became Director of External Relations for the Institute. He was a charter member of the Canadian Society of Technical Agriculturists and of the Quebec Society for the Protection of Plants and served the latter as president from 1925 until 1928. He was president of the Entomological Society of Ontario from 1925 to 1927 and of the Pomological Society of Quebec in 1917. Father Leopold served as a member of the executive of the National Advisory Committee on Agricultural Services in Canada and as a member of the Associate Committee on Agriculture of the National Research Council of Canada. He was an officer of the "Mérite Agricole de France," and he was awarded the honorary degree D.S.A. (Doctor of Science in Agriculture) by the University of Montreal in 1927.

Father Leopold's was a busy pen and produced a constant stream of articles on horticultural subjects for the popular press. He was the author of two books, *La Culture Fruitière dans la Province de Québec,* which appeared in 1914, and *La Culture des Fleurs et le Jardin Paysager,* published first in 1935 and in a third edition in 1945.

His broad contacts, with students and colleagues at Oka and the University of Montreal, with the Church, with horticulturists and entomologists, made Father Leopold many things to many people. He was said to be an exacting teacher, but he is known best to some of us as a genial student of nature and an enthusiastic collector of insects, especially Coleoptera. A large collection of insects remains at Oka as a result of his entomological interests.

FURTHER NOTES ON THE SUBARCTIC ODONATA OF NORTH AMERICA

BY E. M. WALKER,
Department of Zoology, University of Toronto.

Since the writer's report on "The Subarctic Odonata of North America"* was published, several collections have been received from localities included within the territory covered in that paper, which add materially to our knowledge of the dragonfly fauna of the Hudsonian Zone on this Continent. Most of these collections are from the Northwest Territories but a few are from northern Alberta and Newfoundland.

The principal collections received are from the vicinity of Great Slave Lake, Mackenzie District, N. W. T., for which we are indebted to Dr. John Oughton, formerly of the Royal Ontario Museum of Zoology† and his assistants, Messrs. J. R. Vockeroth and Elmer N. Reich. Dr. Oughton spent the summers of 1944, 1945 and 1946 in limnological investigations of Great Slave Lake, under the Fisheries Research Board of Canada and the immediate direction of Dr. D. S. Rawson. This work left little time for collecting dragonflies, yet the collections number nearly 400 specimens, the great majority of which were taken by Mr. Vockeroth. We include also records of thirteen specimens from Great Bear Lake, Mackenzie District, N. W. T., taken in 1945 by Dr. R. B. Miller and Dr. W. A. Kennedy, a few from Fort Smith and other localities in northern Alberta, and twenty from Newfoundland by Dr. F. P. Ide.

The number of species known from the Northwest Territories is increased by these records from 20 (1943) to 30, those from Newfoundland from 24 to 26, while two are added to the list of subarctic species, viz. *Coenagrion angulatum* Walk. and *Sympetrum madidum* Hag.

The abbreviations used in this paper for names of collectors are the following:

Dr. W. A. Kennedy and Dr. R. B. Miller	K. & M.
Dr. John Oughton	J. O.
Dr. D. S. Rawson	D. S. R.
Elmer N. Reich	E. N. R.
J. R. Vockeroth	J. R. V.

Great Slave Lake is abbreviated G. S. L. and Great Bear Lake, G. B. L.

ADONATA FROM THE NORTHWEST TERRITORIES

ZYGOPTERA

Lestes dryas Kirby

Gros Cap, G. S. L. Aug. 1, 3, 1945, 2 ♂; July 28, 1946, 1 ♀; Aug. 11, 1946, 2 ♂ (J. R. V.). Total 4 ♂ 1 ♀.

Lestes disjunctus Selys

Bog lake near rapids Yellowknife River. N. W. T., July 18, 1944, 4 ♂ 5 ♀ and 1 exuvia; slough, delta of Slave River, G. S. L., 3 ♂ (J. O.); Gros Cap, G. S. L., July 22-28, 1946, 11 ♂ 10 ♀; Aug. 12, 3 ♂ 1 ♀, including pair *in copula* (J. R. V.); Wilson I., G. S. L., Aug. 6, 1946, fragments of 1 ♂ (J. R. V.). Total 27 ♂ 16 ♀.

The specimens taken on the Yellowknife River on July 18 and those taken on Gros Cap on July 22 (4 ♂ 6 ♀) are all teneral, 2 ♂ from the latter locality being just emerged. Of the 4 ♂ 2 ♀ taken July 27, 3 ♂ are mature, the others teneral; and of the three taken July 28, 2 ♂ are mature but the ♀ had just emerged. The August specimens are all mature. It would thus appear that on the north shore of Great Slave Lake the season of emergnce of this species begins about the middle of July, although no doubt there is some variation from year to year as in every locality. This period of emergence is about the same as in southern Ontario.

*Walker, E. M., 1943, *Can. Ent.*, 75, No. 5, 79-90.
†Now on the staff of the Ontario Agricultural College, Guelph, Ont.

Enallagma boreale Selys

Bog lake near rapids, Yellowknife River, N. W. T., July 18, 1944, 4 ♂ (J. O.); Gros Cap, G. S. L., June 20, 1945, 10 ♂ 6 ♀; July 22-28, 1946, 14 ♂ 2 ♀ (J. R. V.). Total 28 ♂ 8 ♀.

All the June specimens except 1 ♀ are teneral, while the July specimens are all mature. This suggests a season later than in southern Ontario, but probably similar in relation to seasonal events.

Enallagma cyathigerum Charp.

Mouth of Little Buffalo River, G. S. L., June 25, 1945, 3 ♂ (J. O.); Green I., G. S. L., June 27, 1945, 1 ♀ (E. N. R. and J. O.); Tochatiwi Bay, G. S. L., July 7, 1946, 1 ♀ (J. R. V.); Gros Cap, G. S. L., Aug. 13, 1944, 1 dead ♀ floating (J.O.); July 28, 1946, 1 ♂ (J. R. V.); Outpost I., G. S. L., July 3-29, 1945, 13 ♂ 1 ♀ (J. R. V.). Total 17 ♂ 4 ♀.

Most of the above specimens are mature. The season is probably about the same as for *E. boreale*.

Coenagrion resolutum Hagen

Fort Smith, Alta., June 8, 1944, 1 ♀ (E. N. R.); Fort Resolution, G. S. L., semi-permanent slough, June 19, 1945, 1 ♀ (J. O.), June 23, 1944, 1 ♀ (J. O.); Green I., G. S. L., June 27, 1945, 1 ♀ (E. N. R. and J. O.); Rae, July 7, 1944, 1 ♂ (Pete Larkin); bog lake near rapids, Yellowknife River, July 18, 1944, 2 ♂ (J. O.). Total 3 ♂ 4 ♀.

The seasonal range as indicated by the above dates appears to be only slightly later than in southern Ontario where it begins usually near the end of May and is over early in July.

Coenagrion interrogatum Hagen

Gros Cap, G. S. L., June 6, 1946, 1 ♀ (J. R. V.).

This is the first record of this species from the Northwest Territories, but it was expected here.

Coenagrion angulatum Walk.

Fort Smith, Alta., June 6, 1946, 2 ♂ (J. R. V.); Fort Resolution, G. S. L., semi-permanent slough, June 19, 1945 1 ♂ (J. O.); Resdelta, June 6, 1946, 1 ♂ 3 ♀ (J. R. V.). Total 4 ♂ 3 ♀.

These are the most northerly records for this species and the first from the Northwest Territories. It also makes an addition to the Odonata of the Hudsonian Zone. The specimens are rather large.

ANISOPTERA

Aeshna eremita Scudd.

Fort Smith, Alta., Sept. 6, 1946, 1 ♀; near Rae, G. S. L., small beaver pond beside Frank Channel, July 4, 1944, exuviae of ♂ and ♀; Rae, July 7, 1944, 1 ♂ 2 ♀, all mature (J. O.); Yellowknife, July 17, 1944, 1 ♂ (J. O.); July 22, 1945, 1 ♀ (J. R. V.); Yellowknife River and Rapids, July 18, 1944, 3 ♂ 4 ♀ (J. O.); slough, delta of Slave River, Aug. 8, 10, 1944, 1 ♂ 4 ♀ (E. N. R.); slough, delta of Great Slave Lake, Aug. 1, 1944, 1 ♂ exuvia (J. O.); Outpost I., G. S. L., July 20-30, 1945, 2 ♂ 2 ♀ (J.R.V., D. S. R., and J. O.); Gros Cap, G. S. L., Aug. 1-4, 1945, 7 ♂ 7 ♀ (J. R. V.); July 24-28, 1946, 3 ♂ 2 ♀, Aug. 11, 1 ♂ (J. R. V.); s. end of Tochatiwi Bay, G. S. L., July 7, 1946, 1 ♂ 1 ♀ (J. R. V.); bog lake, Pearson's Pt., Christie Bay, G. S. L., Aug. 10, 1946, 1 exuv., 2 nymphs, final and penult. instars (J. O.); Fort Radium G. B. L., July 6, 7, 1945, 2 ♀ (K. & M.); 20 mls. n. of Fort Radium, G. B. L., July 12, 1945, 1 ♂ (K. & M.); Conjuror Bay, G. B. L., July 19-23, 1945, 3 ♂ 5 ♀ (K. & M.). Total (adults) 24 ♂ 35 ♀.

Teneral individuals were taken in the Great Slave Lake region on July 18 but mature specimens were also taken on that date and even on July 7. The earliest record from this region is June 27 (Walker '43) and it is everywhere a comparatively early Aeshna. The above records, however, indicate that emergence may continue until the middle of July.

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Aeshna interrupta lineata Walk.

Fort Chipewyan, Lake Athabaska, Alta., July 3, 1945, 1 ♂; Aug. 17, 1945, 1 ♂ 1 ♀; Fort Smith, Alta., Sept. 6, 1946. 1 ♂; Fort Resolution, G. S. L., July 28, 1945, 1 ♀ (J. R. V.); Outpost I., G. S. L., July 30, 1945, 4 ♀ (J. R. V.); Red Rock, G. S. L., 1 ♂ (E. N. R.); slough, delta of Slave River, G. S. L., Aug. 1, 1944, 1 ♀ (J. O.); Hay River Settlement, Great Slave River bank, Aug. 4, 1944, 1 ♂ (E. N. R.); Gros Cap, G. S. L., Aug. 1-4, 1945, 2 ♂ 6 ♀ (J. R. V.); July 28, 1946, 1 ♀ (J. R. V.); Utsingi Pt., G. S. L., Aug. 17, 1945, 1 ♀ (J. R. V.). Total 8 ♂ 16 ♀.

All of this series are definitely of the race *lineata*. The dates are all in August or the last four days of July and the period of flight is thus definitely later than that of *A. eremita*, as it appears to be everywhere.

Aeshna juncea americana Bart.

Fort Smith, Alta., Sept. 6, 1946, 1 ♂; Gros Cap, G. S. L., Aug. 1-3, 1945, 3 ♂ 3 ♀ (J. R. V.); Taltheiler Narrows, G S. L., Aug. 7, 1945, 1 ♂ 1 ♀ *in copula* (J. R. V.); Pearson Pt., Christie Bay, G. S. L., Aug. 8, 1946, 1 ♀ (J. O.); Port Radium, G. B. L., July 7, 1945, 1 ♀ (K. & M.). Total 4 ♂ 6 ♀.

Aeshna subarctica subarctica Walk.

Pearson Pt., Christie Bay, G. S. L., Aug. 8, 1946, 1 ♀ from a small bog lake (J. O.); Aug. 21, 1946, 1 ♂ (J. R. V.); Aug. 7, 1946, 1 nymph, antepenult. instar, and 1 ♀ exuvia (J.O.).

The only previous record of this species from the Northwest Territories was from Great Bear Lake (Walker, '43).

Aeshna sitchensis Hagen

Outpost I., G.S.L., July 26, 1945, 2 ♂ (J. R. V.).

Aeshna umbrosa umbrosa Walk.

Mouth of Hay River, G. S. L., Aug. 4, 1944, 1 ♂ (E. N. R.).

Ophiogomphus colubrinus Selys

Fort McMurray, Alta., June 7, 1944, 1 ♂, teneral, (Wynn-Edwards and Ronald Grant), June 8, 1944, 2 ♀, teneral, (E. N. R.).

Cordulia shurtleffi Scudd.

Fort Smith, Alta., June 9, 1944, 1 ♀ (J. O.); Gros Cap, G.S.L., June 17–25, 1946, 21 ♂ 22 ♀ (J. R. V.); Caribou I., G.S.L. June 25, 1946, 3 ♂ 1 ♀ (J. R. V.); Wilson I., G.S.L., June 26, 1946, 1 ♂ (J.R.V.); Pearson Pt., Christie Bay, G. S. L., Aug. 10, 1946, 1 full-grown nymph from bog lake (J.O.).

The females taken at Gros Cap on June 17 and 19 are teneral with amber or smoky wings. Of the fifteen females taken there on June 20 all appear to be rather past the teneral stage, although seven have the wings decidedly amber-tinted. Those taken on June 23 and 25 are all mature or nearly so, the wings with a slight amber tint. The males appear to be all mature, except one taken June 19.

It is noteworthy that this entire series was taken during June. This seems everywhere to be the month when Cordulia is at its height of abundance.

Somatochlora hudsonica Hagen.

Gros Cap, G.S.L., June 20, 1946, 2 ♀; Caribou I., G.S.L., June 25, 1946, exuvia of ♂.

One of the females is somewhat teneral with dark amber wings.

Libellula quadrimaculata L.

Fort Smith, Alta., June 8, 9, 1944, 1 ♂ 1 ♀ (E. N. R.); bank of Slave River, 120 mls. downstream from Fort Smith, June 15, 1945, 1 ♀ (J.O.); Fort Resolution, G. S. L., June 22, 1945, 1 ♀ (J.O.).

Sympetrum internum Montg.

Near bog lake, Yellowknife Rapids, N. W. T., July 18, 19, 1944, 1 ♂ 1 ♀ (J.O.); delta of Slave River, near McDonald's Lake, abundant at Willow-Equisetum slough, Aug, 1, 1944, 3 ♂ 3 ♀ (J. O.); Gros Cap. G.S.L., Aug. 2–5, 1945, 4 ♂ 3 ♀ (J. O.); Aug. 11–14, 1946, 48 ♂ 20 ♀ (J.R.V.); Fort Resolution, G.S.L., July 13, 1946, 1 ♀ (J. R. V.); Outpost I., G.S.L., Aug. 23, 1945, 1 ♂

(J. O.). Total 57 ♂ 28 ♀.

Nearly all of this series are mature, the only exceptions being a female, July 13, and another, Aug. 11, which are in the ochraceous phase. Pairs *in copula* were taken at Gros Cap, one on Aug. 11 and seven on Aug. 14.

The specimens are of average to rather small size and belong to the western race in which the venation is reddish, not dusky as in eastern specimens.

Sympetrum madidum Hagen

Delta of Slave River at Great Slave Lake, Aug. 1, 1944, 1 ♂ (J. O.).

This is the greatest surprise of the collection. Although only one specimen was taken, the label bears a note to the effect that this species was much scarcer than *S. internum*. This is at least an indication that other individuals were seen. No other records suggest that *S. madidum* penetrates even the Canadian Zone very far. We have considered it a species mainly of the Western Transition Zone.

Sympetrum costiferum Hagen

Outpost I., G.S.L., Aug. 23, 1945, 1 ♂ (J. R. V.).

Sympetrum danae Sulzer

Fort Smith, Alta., Sept. 18, 1945, 1 ♂; Sept. 6, 1946, 1 ♀ (J.R.V.); Yellowknife, N.W.T., Aug. 10, 1946 1 ♂ 2 ♀ (J.R.V.); Fort Resolution, G.S.L., Aug. 15, 1946, 1 ♂ 1 ♀ (J.R.V.); Gros Cap, G.S.L., Aug. 11–14, 1946, 5 ♂ 6 ♀ (J. R.V.); Sept. 6, 1946, 2 ♂ (D.S.R.); Outpost I., G.S.L., Aug. 23–28, 1945, 9 ♂ 2 ♀ (J.R.V.). Total 19 ♂ 12 ♀.

One pair was taken in copula at Gros Cap on Aug. 12. Most of the specimens are somewhat teneral or juvenile. Mature individuals were taken on Aug. 23 and 24. 1945.

Leucorrhinia borealis Hagen

Slave River, 12 mls. downstream from Fort Smith (Alta.), N.W.T., June 15, 1945, 1 ♀ (J.O.); Caribou I., G.S.L., June 25, 1946, 1 ♀ (J.R.V.).

Leucorrhinia hudsonica Selys

Gros Cap, G.S.L., June 20, 1946, 1 ♀, (J.R.V.); Tochatiwi Bay, G.S.L., July 7, 1946, 1 ♂ 1 ♀ (J.R.V.); Pearson Pt., Christie Bay, G.S.L., Aug. 7, 1946, 1 full-grown nymph from small bog pond (J.R.V.); Port Radium, G. B. L., July 16, 1945, 1 ♂ (K. & M.)

The adult specimens are all mature and rather old. The scarcity of this common species in the collection is remarkable.

Leucorrhinia patricia Walk.

Gros Cap, G.S.L., June 20, 1946, 1 ♂ (J.R.V.); Outpost I., G.S.L., July 3, 1945, 1 ♂ (J.R.V.).

These are the first records of this species outside of Ontario. The male is larger than any specimens hitherto reported.

Leucorrhinia proxima Calvert

Gros Cap, G.S.L., June 25, July 27, 1946, 1 ♂ 2 ♀ (J.R.V.); Outpost I., G.S.L., July 3, 1945, dead ♂, floating; Caribou I., G.S.L., June 25, 1946, 1 ♂ 1 ♀ (J.R.V.); Pearson Pt., Christie Bay, G.S.L., Aug. 10, 1946, 1 exuvia at bog pond (J.O.). Total (adults) 3 ♂ 2 ♀.

LIST OF ODONATA KNOWN FROM THE NORTHWEST TERRITORIES

ZYGOPTERA

LESTIDAE

Lestes dryas Kby.
Lestes disjunctus Selys

COENAGRIIDAE

Enallagma boreale Selys
Enallagma cyathigerum Charp.
Coenagrion resolution Hagen
Coenagrion interrogatum Hagen
Coenagrion angulatum Walk.

ANISOPTERA

AESHNIDAE

Aeshna eremita Scudd.
Aeshna interrupta lineata Walk.
Aeshna juncea americana Bart.
Aeshna subarctica subarctica Walk.
Aeshna sitchensis Hagen
Aeshna coerulea septentrionalis Burm.
Aeshna umbrosa umbrosa Walk.

GOMPHIDAE

Ophiogomphus colubrinus Selys

CORDULIIDAE

Cordulia shurtleffi Scudd.
Somatochlora franklini Selys.
Somatochlora kennedyi Walk.
Somatochlora forcipata Scudd.
Somatochlora septentrionalis Selys
Somatochlora hudsonica Hagen

LIBELLULIDAE

Libellula quadrimaculata L.
Sympetrum internum Montg.
Sympetrum madidum Hagen.
Sympetrum costiferum Hagen.
Sympetrum danae Sulz.
Leucorrhinia borealis Hagen.
Leucorrhinia hudsonica Selys.
Leucorrhinia patricia Walk.
Leucorrhinia proxima Calvert.

ODONATA FROM NEWFOUNDLAND

The following were collected by Dr. F. P. Ide, of the Department of Zoology, University of Toronto, all from the Avalon Peninsula of southeastern Newfoundland.

Lestes disjunctus Selys

Ocean Pond, Whitbourne, Aug. 13, 1944, 2 ♂.

This transcontinental species has been long expected to occur in Newfoundland, but has hitherto not been reported.

Aeshna eremita Scudd.

Hell Hole Pond, Aug. 27, 1944, 2 ♂ 1 ♀; Tors Cove. Aug 26, 1944, 2 ♀.

Aeshna interrupta interrupta Walk.

Hell Hole Pond, Aug. 27, 1944, 1 ♂.

Aeshna umbrosa umbrosa Walk.

Hell Hole Pond, Aug. 27. 1944, 1 ♂; on the road between New Harbour and Spaniard's Bay, Aug. 14, 1944, 2 ♂ 1 ♀; Torbay, Aug. 31, 1944, 1 ♂.

Ophiogomphus colubrinus Selys

Trinity Bay, Aug. 13, 1944, 1 exuvia.

Somatochlora walshii Scudd.

On the road between New Harbour and Spaniard's Bay, Aug. 14, 1944, 1 ♂; Torbay, small stream, Aug. 31, 1944, 1 ♀.

This is a new record for Newfoundland.

Somatochlora cingulata Selys.

On the road between New Harbour and Spaniard's Bay, Aug. 14, 1944, 1 ♂; Torbay, small stream, Aug. 3, 1944, 1 ♀.

Sympetrum danae Sulz.

Tors Cove, Aug. 27, 1944, 1 ♂; Torbay, Aug. 31, 1944, 2 ♂ 1 ♀, including a pair *in copula*.

LIST OF ODONATA KNOWN FROM NEWFOUNDLAND

ZYGOPTERA

LESTIDAE

Lestes disjunctus Selys

COENAGRIIDAE

Enallagma boreale Selys
Enallagma cythigerum Charp.
Enallagma ebrium Hagen
Coenagrion resolutum Hagen
Coenagrion interrogatum Selys
Ischnura verticalis Say.

ANISOPTERA

AESHNIDAE

Aeshna eremita Scudd.
Aeshna interrupta interrupta Walk.
Aeshna canadensis Walk.
Aeshna juncea americana Bart.
Aeshna sitchensis Hagen
Aeshna coerulea septentrionalis Burm.
Aeshna umbrosa umbrosa Walk.

GOMPHIDAE

Ophiogomphus colubrinus Selys

CORDULIIDAE

Cordulia shurtleffi Scudd.
Somatochlora walshii Scudd.
Somatochlora forcipata Scudd.
Somatochlora septentrionalis Selys
Somatochlora albicincta Burm.
Somatochlora cingulata Selys
Libellula quadrimaculata L.
Sympetrum costiferum Hagen
Sympetrum danae Sulz.
Leucorrhinia hudsonica Selys

A DIPTEROUS INSECT NEW TO QUEBEC, *ACROCERA STEYSKALI* SABR.*

I had recently the pleasure of receiving from Mr. J. I. Beaulne of Quebec City an interesting dipterous insect for identification. The locality label attached to the specimen read "Lachine, Que., 4, IX, 43, J. I. Beaulne." The insect belonged to the genus *Acrocera* of the family Acroceridae and did not match any of the specimens in the collection of the University of Montreal. I sent it to Mr. G. E. Shewell of the Department of Agriculture, Ottawa, for identification. Mr. Shewell kindly replied, stating that the fly was *Acrocera steyskali* Sabr., a new record for Quebec. He further stated that the species was described quite recently from northeastern United States material and that he did not think it had been recorded from anywhere in Canada.

The Acroceridae are a small family composed of very rare insects. There are at most 200 species known in the world. They may be recognized at once by the small head, the swollen thorax, and inflated abdomen. They are known to be parasitic on spiders.

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*Received for publication March 27, 1946.

NEW NEARCTIC CRANE-FLIES (TIPULIDAE, DIPTERA): PART XXVIII.

BY CHARLES P. ALEXANDER,
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The preceding part under this title was published in 1947 (Can. Ent., 78: 155-159). At this time I am describing four species of the genus *Tipula* from Arizona and California, the types being preserved in my collection except where indicated to the contrary in the text.

Tipula (Trichotipula) prolixa n. sp.

Mesonotum brownish gray, the praescutum with four very poorly differentiated darker stripes; antennae short; wings with a strong brownish yellow tinge, the prearcular field, costal border and stigma more saturated brownish yellow; macrotrichia in the outer ends of cells R_5 and M_1; *Rs* short, subequal to R_2+_3; abdomen of male unusually long; male hypopygium with the beak of the inner dististyle long-produced, slender, the lower beak subbasal in position, appearing as a slender sclerotized arm.

Male. Length about 16-17 mm.; wing 12-13.8 mm.; abdomen alone 12-13 mm.; antenna about 2-2.2 mm.

Frontal prolongation of head yellow, relatively long but shorter than the remainder or head; nasus elongate; palpi obscure yellow. Antennae (male) short; scape yellow, pedicel more testaceous, flagellum dark brown; flagellar segments simple or virtually so, the longest verticils exceeding the segments. Head above obscure brownish yellow, gray pruinose; a more or less distinct median brown line; vertical tubercle low and simple.

Pronotal scutum pale, sparsely pruinose; scutellum and pretergites light yellow. Mesonotal praescutum with the ground brownish gray, with four very poorly differentiated stripes, best indicated by narrow brown margins, the capillary median one most distinct; posterior sclerites of notum brown, sparsely pruinose, parascutella and katapleurotergite clearer yellow; postnotal mediotergite with a vague obscure yellow central line. Pleura yellow, more or less pruinose. Halteres with the stem yellow, knob infuscated. Legs with the coxae yellow, sparsely pruinose; trochanters yellow; femora and tibae yellow, the tips more infuscated, tarsi passing into black; claws (male) toothed. Wings with a strong brownish yellow tinge, the prearcular field, cell Cu_1, costal border and stigma more saturated brownish yellow; veins pale brown. No squamal setae; relatively numerous macrotrichia in outer third of cells R_5 and M_1, especially the former; no stigmal trichia. Venation: *Rs* short, subequal to the second section M_1+_2 or to R_2+_3; R_1+_2 preserved; petiole of cell M_1, shorter than *m;* Cell 1st M_2 narrow M_3+_4 short, about one-third to one-half the basal section of M_1+_2; *m-cu* on M_4 shortly beyond the perpendicular origin.

Abdomen of male unusually long; tergites infuscated medially above, paling to obscure yellow on sides, the outer segments, and especially the sternites and hypopygium more uniformly obscure yellow. Male hypopygium having the ninth tergite with a deep V-shaped notch, the lateral lobes with retrorse blackened spinous setae. Outer dististyle moderately long, its greatest width about one-fourth the length, provided with scattered yellow setae. Inner dististyle with the beak long-produced, slender; lower beak subbasal in position, appearing as a slender sclerotized arm, the apex subcultrate in outline; on side of style above the lower beak with a low darkened flange; surface above this flange and onto the base of beak with strong dark-colored setae.

Habitat. Arizona (Cochise County).

Holotype. ♂, Silver Creek, Chiricahua Mts., altitude 4500-6000 ft., October 3, 1927 (J. A. Kusche); California Academy of Sciences, through Dr. Edward S. Ross, Curator of Insects. *Paratopotype.* ♂. *Paratype.* ♂, Tex Canyon, Chiricahau Mts., altitude 4500-6000 ft., October 8, 1927 (J. A. Kusche).

The present fly is quite distinct from the other regional members of the subgenus, differing in the coloration of the wings, elongate abdomen and structure of the male hypopygium. In some regards it is more similar to certain Mexican species, such as *Tipula (Trichotipula) religiosa* Alexander and *T. (T.) vultuosa* Alexander, yet quite distinct in hypopygial structure.

Tipula (Lunatipula) biproducta n. sp.

Belongs to the *impudica* group; size medium (wing, male, 15.5 mm.); general coloration brownish gray to gray, the praescutum with four darker brown stripes; basal flagellar segments weakly bicolored; wings with the ground color weakly infuscated, restrictedly patterned with darker brown and whitish subhyaline, the latter pattern in female more extensive and contrasted; male hypopygium having the basistyle and sternite fused into a single structure, the outer portion of the former narrowed and produced into a powerful spine.

Male. Length about 17 mm.; wing 15.5 mm.; antenna about 5 mm.

Female. Length about 21 mm.; wing 18 mm.

Frontal prolongation of head obscure yellow in male, much darker and pruinose basally in female; nasus short and stout; palpi in male with proximal segments brownish yellow, the terminal one black; in female, basal segments more infuscated. Antennae (male) with proximal three segments yellow, succeeding segments obscurely bicolored, the basal swellings dark brown, the outer portions brown, at tips even paler; outer segments more uniformly darkened; flagellar segments with rather prominent basal enlargements. Head brownish gray, with a conspicuous narrow dark brown median vitta.

Pronotum brown to brownish gray, vaguely marked with darker. Mesonotal praescutum with the ground brownish gray (in male) to darker gray (female), with four darker brown stripes, the intermedite pair forming the lateral borders of the broad median ground stripe, lateral stripes broader; scutal lobes each with two brown spots; posterior sclerites of notum light brown or brownish gray, with a narrow brown median vitta, more distinct on the scutellum. The coloration in the female is definitely grayer and darker. Pleura and pleurotergite chiefly pale brownish yellow, a little darker and more pruinose on the sternopleurite. Halteres with stem yellow, knob more or less darkened and variegated with pale. Legs with the coxae obscure yellow, sparsely pruinose; trochanters yellow; femora obscure yellow, the tips rather narrowly brown or brownish black, the amount subequal on all legs; tibiae obscure yellow, the tips very narrowly infuscated; tarsi passing into black; claws (male) toothed. Wings of male with a weak brownish tinge, the prearcular and costal fields more yellowed; a vague darkening in cell *M* adjoining vein *Cu* and in outer ends of cell R_2 and R_3; stigma brown, its cephalic portion paler; prestigmal obliterative area relatively conspicuous, especially across cell 1*st* M_2, involving the bases of cells M_3 and M_4; poststigmal brightening less conspicuous; in female, the pattern more contrasted, the white areas, especially the band at cord, very wide and broadly reaching the posterior margin in cells M_3 and M_4; poststigmal brightening more conspicuous; cell R_5 more or less whitened, as are the tips of the outer cells at wing apex; distinct white streaks along vein 1*st A* and more caudad in the same cell; veins brown, pale in the brightened areas. Venation: *Rs* relatively short, scarcely twice *m-cu*; R_{1+2} entire; *m* and petiole of cell M_1 subequal or the latter longer (in male).

Abdominal tergites obscure yellow, with three broken stripes, the median one forming linear brown streaks, most evident on segments three to five; lateral stripes represented by darker but still smaller spots, best indicated on the posterior ring of tergite two and on basal portions of tergites three to five; lateral tergal borders broadly, the posterior margins more narrowly yellow; outer segments more uniformly yellow; sternites yellow, the outermost more discolored. Male hypopygium when viewed from the side showing the tergal canthi directed chiefly dorsad, their tips caudad; basistyle and ninth sternite completely fus-

ed, the produced apex of the former directed caudad and slightly ventrad. Ninth tergite with the canthi, as viewed from above, appearing as triangular plates, the small apical points incurved, the mesal edge with small setigerous tubercles to produce a roughened appearance; median lobe (subtergal process) extended beyond the tips of the canthi, compressed-flattened on dorsal portion, more expanded laterally below, the apex produced into pale shapeless membrane; lateral processes very broadly triangular, their tips obtuse. Outer portion of region of basistyle produced caudad into a powerful pointed spine, as described, provided with scattered setae except on the more sclerotized outer third. Outer dististyle expanded basally, the apical half slender and attenuated, the more basal setae unusually long, approximately two-thirds the length of style. Inner dististyle with the beak and lower beak broad; dorsal crest very low; posterior crest unusually small, separated from the end of the outer basal lobe by a notch; style unusually glabrous; outer basal lobe a little shorter than the main body of style, the posterior end produced into a strong spine that is stouter than the somewhat comparable one of the basistyle, its tip obliquely truncated, provided with setae over almost its entire length; an extensive area of dense delicate setae; sensory area small but compact, consisting of from 15-18 pores. Eighth sternite sheathing, the apex broadly truncate, with small oval lateral lobes that bear abundant elongate roughened setae; the broad median area between the lobes with a fringe of similar setae; in the membrane with a stout dusky median lobe, somewhat as in *mitrata* and other species.

Habitat. California (San Diego County).

Holotype. ♂, Borego, California Painted Desert, April 21, 1944 (J. L. Sperry). *Allotopotype.* ♀.

The present fly is readily told from all other members of the *impudica* group by the structure of the male hypopygium, especially the produced basistyle, a unique character in the group. In other regards, it is most similar to species such as *Tipula* (*Lunatipula*) *carunculata* Alexander, *T.* (*L.*) *diversa* Dietz and *T.* (*L.*) *lyrifera* Dietz.

Tipula (Lunatipula) spinerecta n. sp.

Size medium (wing, male, about 17 mm.); mesonotum gray, the praescutum with four brown stripes; antennae with scape and pedicel yellow, flagellum black; wings whitish subhyaline, restrictedly clouded with brown, most heavily in the outer ends of cells R_3 and R_2; obliterative band before cord extending from vein *R* to the posterior border, including all of cell 1*st* M_2; abdominal tergites obscure yellow, trivittate with brownish black, the middorsal stripe very conspicuous; male hypopygium with the caudal border of tergite emarginate, the lateral lobes subacute; a median tergal lobe that terminates in a compressed pale spatulate blade; basistyle with its dorsal margin produced into a very powerful erect black spine.

Male. Length about 16—17 mm.; wing 16—17 mm.; antenna about 4.5 mm.

Frontal prolongation of head obscure yellow, more infuscated on ventral surface, the dorsal area light gray pruinose; nasus short and stout; palpi black. Antennae (male) relatively short; scape and pedicel yellow; first flagellar segment black, its proximal end obscure yellow, remainder of organ black; flagellar segments feebly incised; longest verticils subequal in length to the segments. Head light gray, the vertex with a narrow dark median line; vertical tubercle very low.

Pronotal scutum gray, with three brown spots; scutellum above clear light yellow. Mesonotum gray, the praescutum with four brown stripes, the intermediate pair narrow, especially behind, forming the lateral borders of a wider more plumbeous central stripe; posterior sclerites of notum gray, each scutal lobe with two slightly darker areas; scutellum and mediotergite gray, with

a brown central line. Pleura light gray, the broad dorsopleural region light yellow. Halteres with stem yellow, knob dark brown. Legs with the coxae light gray; trochanters yellow, the tips narrowly brownish black; tibiae obscure brownish yellow, the tips narrowly dark brown; tarsi brownish black; claws slender, toothed. Wings whitish subhyaline, restrictedly clouded with brown, most heavily so in outer ends of cells R_2 and R_3; cells behind vein *M* more extensively clouded with paler brown, variegated by the ground, including streaks at base of Anal cells and along vein 1*st A;* obliterative band before cord extending from *R* to the posterior border, including all of cell 1*st* M_2 and much of cell M_4; cells *R M* and R_1 extensively whitened; post-stigmal brightening relatively restricted; outer ends of cells R_5 and M_1 whitened; prearcular and costal fields more yellowed; veins brown, paler in the brightened fields. Squamal setae few. Venation: *Rs* long, nearly three times *m-cu;* R_1+_2 entire; M_3+_4 and basal section of M_1+_2 subequal.

Abdominal tergites obscure yellow, with a conspicuous, almost entire brownish black central stripe; sublateral portions of tergites with an even broader brownish black line that is more or less pruinose; lateral tergal borders more buffy; sternites pruinose, the central portion more infuscated. Male hypopygium having the ninth tergite entirely separate from the ninth sternite; basistyle separated from the ninth sternite by the ventral suture only. Ninth tergite transverse, gently narrowed outwardly, the caudal margin with a U-shaped notch, the subtending angles produced into subacute lobes; from the base of the notch extends a more slender median arm that terminates in a compressed pale spatulate blade that is densely setuliferous. Ninth sternite with its appendage unequally bilobed, the low dorsal lobe with coarse erect setae; lower lobe much smaller, its setae very long, exceeding the lobe in length. Basistyle with the ventral or outer end slightly produced into an obtuse lobe; dorsal margin bearing a very powerful erect black spine, directed dorsad. Outer dististyle very broad at base, more narrowed outwardly, the apex obtuse; posterior margin with coarse erect setae. Inner dististyle with both beak and lower beak blackened, the latter more pointed; beak longitudinally corrugated; outer basal lobe large and conspicuous, flattened, erect, its apex truncated or virtually so; sensory area on body of style opposite the notch. Eighth sternite moderately sheathing, the caudal margin nearly truncate, with a low central cushion that bears numerous very long yellow setae from conspicuous darkened bases.

Habitat. California (Kern County).

Holotype. ♂, Cuyama Valley, April 10, 1932 (E. P. Van Duzee); California Academy of Sciences, through Dr. Ross *Paratopotypes.* 3 ♂ ♂.

The somewhat peculiar armature of the basistyle of the male hypopygium is quite sufficient to separate the present species from all others that have the sclerite produced in various manners. Similarly, the ninth tergite and dististyles show virtually as strong characters. In some regards, particularly the ninth tergite and outer dististyle, a resemblance to members of the *impudica* group is suggested but I hesitate to make a definite group reference at this time.

Tipula (Lunatipula) timberlakei n. sp.

Allied to *modoc;* size small (wing, male, 9 mm.); mesonotum gray, the praescutum with four entire brown stripes; nasus short; antennae relatively short in both sexes, basal three segments yellow, the pedicel clearer yellow, flagellum black; head gray with a central brown line; scutellum and mediotergite with a similar brown stripe; legs brown, claws simple; wings with a brownish tinge, variegated with darker brown and whitish subhyaline, the latter including a small post-stigmal area and a very broad stripe at and before cord, cell 1*st* M_2 chiefly whitened; tergites trivittate with brown, sternites with a long single broad stripe; male hypopygium with the caudal margin of tergite with a very broad V-shaped notch, the margins glabrous; inner dististyle with the outer

basal lobe a long straight pale rod, its base more expanded; sensory area at extreme base of style; phallosome with the apophyses terminating in very long and slender curved horns that are decussate at the midline; eighth sternite with the caudal margin truncate, with a group of about 20 long yellow setae on either side of the midline; ovipositor with the cerci compressed, expanded and tridentate at apex; hypovalvae very deep and compressed, the tips obtusely rounded.

Male. Length about 9 mm.; wing 9 mm.; antenna about 3 mm.

Female. Length about 12–13 mm.; wing 9–11 mm.

Frontal prolongation of head light gray above, obscure yellow on sides and beneath; nasus short; palpi black, terminal segment relatively short. Antennae relatively short in both sexes; scape and first flagellar segment brownish yellow, the pedicel clearer yellow, remainder of flagellum black; flagellar segments moderately incised; verticils shorter than the segments. Head gray, the anterior vertex clearer gray; a central brown line, narrowed to a point behind.

Pronotum gray pruinose, darker medially above, the scutellum yellow. Mesonotal praescutum gray, with four entire brown stripes, the intermediate pair from three to four times as wide as the median ground vitta; scutal lobes brownish gray, the median area paler; scutellum and mediotergite gray with a capillary brown median vitta, less distinct on the latter. Pleura gray; dorsopleural membrane extensively yellow. Halteres brown, the base of stem restrictedly yellow. Legs with coxae gray pruinose; trochanters testaceous brown; remainder of legs brown, the outer tarsal segments darker brown; tips of femora and tibiae not or scarcely darker; claws slender, simple. Wings with a brownish tinge, variegated with darker brown and whitish subhyaline, the brown including the stigma, a spot at origin of *Rs* and a narrow seam over *m-cu;* the whitish areas include a broad mark at and before cord, extending from costa into the bases of cells M_3 and M_4, most extensive in cells *R* and R_1; cell 1*st* M_2 chiefly whitened; a smaller whitened post-stigmal area; prearcular and costal fields more yellowed; veins brown, more brownish yellow in the brightened fields. Squama with a few setae . Venation: Sc_2 ending about opposite midlength of *Rs;* R_1+_2 preserved; cell 1*st* M_2 small; M_3+_4 short, only about one-fourth the basal section of M_1+_2.

First abdominal tergite grayish pruinose, the succeeding ones orange-yellow, conspicuously trivittate with dark brown, the lateral borders broadly light yellow, the caudal margins very narrowly gray; sternites dark brown, the lateral portions extensively yellow; outer abdominal segments more extensively dark brown, the apices of the basistyles yellow. Ovipositor with the cerci compressed, the tips expanded, tridentate, the surface with sparse scattered yellow setae; hypovalvae very deep and compressed, the tips obtusely rounded. Male hyopygium having the ninth tergite transverse, the caudal margin with a very broad V-shaped notch, the lateral lobes relatively narrow, the entire caudal border glabrous. Ninth sternite without a clearly defined lobe or appendage. Outer dististyle much dilated at outer end into a spatula, provided with numerous long coarse setae. Inner dististyle with the beak long-extended, with a blackened point or flange that extends backward as a ridge or carina to the low dorsal crest; lower beak lacking; outer basal lobe a long straight pale rod from a more expanded base, the latter on its lower edge with a few small setae; sensory rear at extreme base of style, composed of about 15 pores. Phallosome with the gonapophyses appearing as inrolled plates to form a somewhat cylindrical structure, the apex of each apophysis further produced into a slender curved horn, these decussate at the midline. Eighth sternite with the caudal margin truncate, on either side of midline with a group of about 20 long yellow setae, these barely decussate.

Habitat. California (Riverside County).

Holotype. ♂, Riverside, March 26, 1937 (P. H. Timberlake). *Allotopotype.* ♀, March 26, 1935 (P. H. Timberlake). *Paratopotypes.* 1 ♀, in copula with the type; 10 ♂ ♀, April 1–2, 1935 (P. H. Timberlake).

This interesting species is named for the collector, Mr. Philip Hunter Timberlake, student of the parasitic Hymenoptera, to whom I am indebted for several interesting crane-flies from California. The species to be most nearly allied to *Tipula* (*Lunatipula*) *modoc* Alexander and *T.* (*L.*) *perfidiosa* Alexander which are readily told by the large size and by all details of structure of the male hypopygia.

BOOK NOTICE

FLEAS OF WESTERN NORTH AMERICA, by Clarence Andresen Hubbard; 533 pp., 15 photographs of Siphonapterists, 95 text figures, 1947. Iowa State College Press, Ames, Iowa. $6.00.

The ever present menace of plague in Western North America has given an impetus, lacking in the East, to the study of the Siphonaptera. The term "Western" in this work is defined as The zone west of the 100th meridian.

Part One of this volume is introductory in nature, consisting of chapters on "Students of Western American Fleas and their Contributions," "The Medical Importance of Fleas," "Field and Laboratory Technique," and "Anatomy of the Flea in Relation to its Taxonomy." Under "The Medical Importance of Fleas" the author has given a summary of plague in Western America, and murine typhus and tularaemia in North America. Reference is made to the Alberta records of plague-infested ground squirrels in the period 1939-1942, to a tularaemia-positive flea and to tularaemia-positive ticks in 1942. With regard to the latter disease, although not mentioned by the author, it is interesting to note that the R.C.A.M.C. plague survey (1943), conducted in Western Canada, records that the disease was wide-spread in Alberta, captured tularaemia-positive animals including rabbits, Richardson's ground squirrels, meadow and white-footed mice, and a Franklin gull.

In Part Two, sixty-six genera comprising some 230 species and subspecies are dealt with in generic sequence suggested to the author by Karl Jordan prior to the publication of the author's checklist of the fleas of the Pacific Northwest of the United States (1940). Keys to families, genera, and to many species are included. Under each species the author has included: description, range, hosts, records, and such bibliography as has been built up since 1939 (the previous bibliography having been thoroughly dealt with by Jellison and Good (1942) in "Index to the Literature of the Siphonaptera of North America"). A useful and admirable feature of the specific descriptions is the inclusion of figures of taxonomic characters of some 250 species.

Part Three comprises a host index and a selected bibliography. The host index includes "Hosts of Western Rodent Fleas, and Fleas of Western Carnivora, Insectivora, Bats, Birds, and Reported from Man."

This volume, which deals with twice as many genera and four times as many species of fleas as have been recorded for Eastern America, should be very welcome to students of the Siphonaptera, and in addition should serve as a handy reference to those entomologists who, from time to time, are concerned with flea problems.

R. H. Ozburn.

A DESCRIPTION OF CAGES USED FOR THE LARGE-SCALE BREEDING OF *STURMIA* SP., A TACHINID PARASITE OF SAWFLIES*

BY H. COPPEL AND H. HOUSE,
Dominion Parasite Laboratory, Belleville, Ontario.

In the establishment of insect parasites, the production of large numbers for release in heavily infested areas is often desirable. This was especially true in the case of parasites of the European spruce sawfly, *Gilpinia hercyniae* Htg. The rapid increase in numbers and extent of the sawfly infestation in Canada with the resulting losses in timber as reported by Balch (1940) and Baird (1940) created a situation of grave concern, and the need for rapid colonization of insect parasites as part of the general control programme was considered urgent. Of the parasites chosen for introduction, the tachinid *Sturmia* sp. was considered very promising. Following initial establishment of this species, it was decided that an attempt should be made to propagate it in numbers sufficient for widespread distribution either by improving the methods in use at that time or by devising radically different methods.

After a thorough study of the usual methods of propagation it was found that production could be increased only by increasing the size of the project staff. Since this was not possible from the standpoint of either available space or personnel a series of investigational studies was undertaken and carried out over a period of three years with the view to the development and use of cages particularly designed for the production of large numbers of parasites. A number of different breeding and rearing cages were constructed, three of which have been used in the routine laboratory production pogramme during the seasons of 1945 and 1946 with excellent results. With few modifications, these might be adapted for large-scale production in the case of many other tachinid parasites having somewhat similar habits.

LIFE HISTORY AND GENERAL METHODS OF LABORATORY PROPAGATION

A brief outline of the life-history of *Sturmia* sp. is necessary for a clear understanding of the methods employed in laboratory breeding. Under controlled laboratory conditions (constant temperature 73°F; constant humidity 60%) the life cycle of *Sturmia* sp. is completed in 25 days. Freshly emerged females are mated with males four or five days old. After a preoviposition period lasting approximatey five days the females deposit macrotype eggs on their hosts and usually continue active oviposition for at least 30 days. The eggs hatch immediately after deposition and the newly emerged larvae pierce the host integument and enter the body cavity. Larval development requires eight to twelve days during which the body contents of the host are entirely consumed. The mature parasite larvae emerge from the host remains and form fragile puparial cases. The pupal stage lasts ten to fifteen days. Male adults usually emerge from the puparial cases one or two days before the females. Weber (1932) gives a detailed account of the biology of *Sturmia inconspicua* Meig., a closely related species.

In general, the laboratory propagation of *Sturmia* sp. involves the parasitism of the host larva by the parasite and the subsequent controlled development of the parasite to maturity. The parasitism of large numbers of host larvae requires the maintenance of a relatively large breeding stock. To obtain ovipositions, three mated female parasites are placed in a small cage with overall dimensions 4 by 4 by 2½ inches. The cage is constructed of basswood or white pine, consisting of a wooden floor, movable xylonite or lucite front, and with sides, top and back of fine-mesh cheesecloth. Into the cage are placed several host larvae in diapause upon which the parasites are allowed to deposit their eggs. After exposure to parasitism the larvae are removed with a camel-hair brush and closely examined for eggs with the aid of a binocular microscope. Those upon which no eggs are found are returned to the cage, while

*Contribution No. 2479, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

those with eggs are prepared for incubation.

Prior to the adoption of the new propagation techniques the parasitized host larvae were placed in 1-inch shell vials, tightly plugged with cotton. The vials were then placed in trays each constructed to hold 100 vials. As a rule, the trays were piled one above the other and a sheet of dampened blotting paper was inserted between each two trays. The trays were first examined four days after parasitism and daily thereafter. Mature parasite larvae, emerging from the host remains, were allowed to form their puparial cases in the vials before being removed from the trays. The puparial cases were handled in two ways: the first consisted of removing the cotton plugs and the host remains from the vials, while the second consisted of removing only the puparial cases. In the case of both methods further incubation treatment was similar. The puparia were placed on dampened sterile moss in a glass-covered emergence

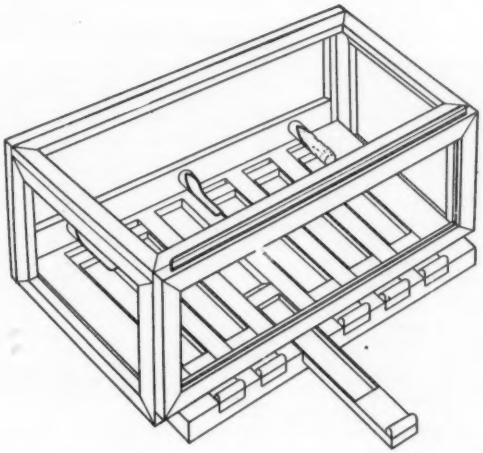

Figure 1. Type of cage used for obtaining mass parasitism.

box. As the adult parasites emerged they were removed from the box and placed in proper containers and a 10 per cent honey and water solution was made available as food. The cages containing flies awaiting release or in oviposition were sprayed twice daily with a fine mist of cold water.

The methods of propagation described entail considerable attention to details. It has been estimated that one-third of the mortality encountered in rearing the parasites can be directly attributed to improper handling of the parasitized host material. In constructing the cages for rearing parasites in large numbers, special attention was, therefore, given to the development of methods whereby the handling of parasitized material would be minimized.

DESCRIPTION OF NEW EQUIPMENT

Cage used for obtaining mass parasitism.

The oviposition cage is somewhat similar to that referred to by Wilkes (1941) for mating sawfly parasites. White pine lumber is used throughout and the cage is of rather simple construction. The overall dimensions are 14⅞ by 9⅜ by 7⅛ inches. It consists of a wooden framework and floor, a movable lucite front, and sides, top and back of fine-mesh cheesecloth. The frames forming the ends, back and top of the cage are made of lumber milled square to ⅝ of an inch. The frame for the front is made of ¾ by 1 inch lumber and is

grooved to accommodate the movable front. In assembling the cage, the frames forming the back, top and front overlap those forming the ends of the cage as shown in Figure 1. The cheeesecloth is glued to the frames before assembling, in such a manner that it is on the inside of the cage when completed.

The floor is made of 1 inch lumber and is 1 inch wider than the width of the cage. Six grooves not quite extending to the back of the cage are cut in the floor to receive the drawers. The drawers are fitted individually so that they can be moved freely in the grooves. The outside dimensions of the drawers are 9 3/16 by 1¼ by 7/16 inches and the inside dimensions are 7 3/16 by 1⅛ by ¼ inches. The ends of the drawers nearest the back of the cage are bevelled in order to prevent the crushing of any flies which happen to be in the grooves when the drawers are moved. A small block of wood fastened to the top of each drawer at its front end serves as a drawer-handle.

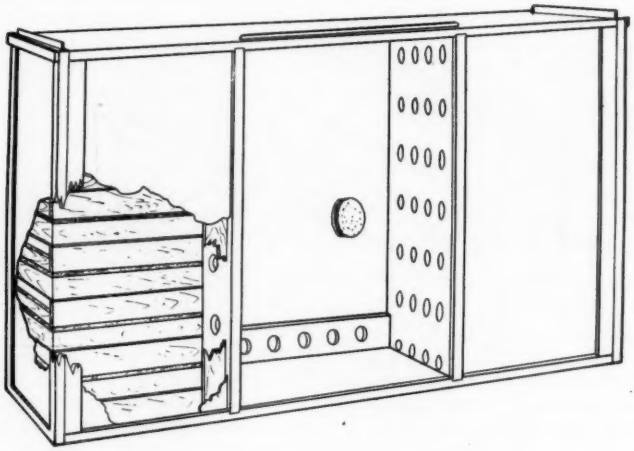

Figure 2. The combination incubation and emergence cage with front and end portion removed to show tray arrangement.

A special feeding device is fastened to the basal portion of the back of the cage. It consists of a board 14⅞ by 1½ by ½ inches through which have been drilled three ¾ inch holes, properly spaced. A food cartridge made of a brass tube 2⅞ inches long is fitted into each hole. A piece is cut out of the tube, extending for 2 5/16 inches of its length, at an angle of 17 degrees. The cartridge is held in place by inserting a pin through holes drilled in the tube and the board. A piece of honey-soaked dental roll is fitted into the cartridge and supplies food for the adult parasites.

The tray used for incubating parasitized larvae.

The incubation tray is constructed of ⅜ inch lumber made into a framework 10⅜ by 7⅝ by ⅞ inches. A grid as shown in Figure 5 is inserted into the bottom of the tray frame and divides the tray into 500 cells, giving it the appearance of honeycomb. The grid is constructed of basswood strips 1/16 by ⅜ inches, sawn half-way through their width at the points of intersection in order that they may be readily fitted together. In order to preserve the wood, both frame and grid are dipped into a liquid mixture of beeswax and resin. The bottom of the tray is covered with 12 mesh wire screening which is fastened to the frame with strips of wood and then drawn up with fine wire to contact the grid at all points.

In addition to the use of the incubation tray as a unit by itself it has been used with considerable success in a double tray arrangement as shown in the centre foreground of Figure 5. The arrangement consists merely of an additional tray with solid floor fastened below the tray containing the grid. The trays are held together with dowel-pins and the ends of the lower tray are not as high as the sides thus allowing adequate ventilation should the units be piled one above the other.

The cage used for the incubation and emergence of the parasites.

The cage (Figure 2) with overall dimensions of 31¼ by 11½ by 16⅜ inches combines into one unit the apparatus necessary for the incubation and emergence of the parasites. The top and bottom of the cage are constructed of 5-ply wood veneer ½ inch thick. Two partitions, fitting into the top and bottom boards and dividing the cage into three compartments, are made of the same material. Each partition is located 9¼ inches from the ends of the cage, thus leaving 11¾ inches for the centre compartment. The frames of

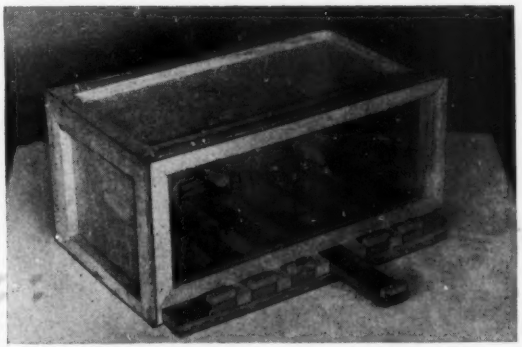

Figure 3. Cage for obtaining mass parasitism shown in use.

the cage are made of white pine milled square to ⅝ of an inch. The ends are enclosed with sheets of masonite extending above the top of the cage and fitting into grooves cut in the end frames. The front and back of the end sections are also made of masonite.

The end compartments are identical in construction, each being sufficiently large to accommodate seven incubation trays similar to those already described. Strips of wood ⅜ by 1 inch are fastened along the inside front and back walls of the cage to support the ends of the trays and on which they can be slipped in and out like drawers. A shelf of masonite is nailed to the bottom of the tray supports below each incubation tray. Seven such shelves divide each compartment into seven sections and provide a space of 1 inch below each tray. Strips of wood ⅜ by ½ inches are nailed along the upper sides of each masonite shelf. To prevent the incubation trays from being inserted too far into the end compartment a strip of 1 inch lumber is milled to fit vertically between the partition and the shelves. The partitions separating the end compartments from the centre compartment are provided with seven rows of holes drilled opposite each shelf. Each row has four 1 inch holes spaced on 2⅜ inch centres. The back of the centre compartment is covered with fine-mesh cheesecloth glued to the frame and held in place with thin strips of wood. The food-board is somewhat similar in construction to that already described, measuring 2 by 2½ inches and containing five ¾ inch holes, drilled 2 inches apart, in which food cartridges are placed. The front of the compartment is closed with a sheet of transparent lucite which can be moved up and down in the grooves

in the front frame. Five holes are drilled through the lucite front, the centre one being 2 inches in diameter while the other four are ¾ inch in diameter. The holes are plugged with cork stoppers.

THE USE OF NEW EQUIPMENT FOR THE LARGE-SCALE PRODUCTION OF INSECT PARASITES

While the general methods of obtaining parasitized hosts remain essentially the same, certain adjustments have been found necessary through the introduction of new-type equipment.

The cage constructed for obtaining ovipositions from large numbers of mated female parasites is shown in operation in Figure 3. Although originally designed to hold 50 ovipositing females, more than this number have been successfully used. The larvae supplied for parasitism are placed in the sliding drawers, and after exposure for from 4 to 8 hours they can be readily removed by pulling out the drawers. The larvae in the drawers are then closely examined with the

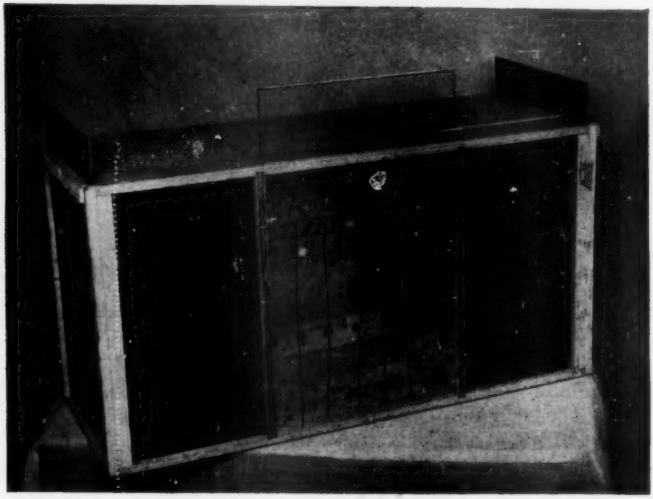

Figure 4. Cage used for incubation and emergence of parasites shown in operation.

aid of a binocular microscope and only those found to be parasitized are removed, thus making it unnecessary for the attendant to handle unparasitized larvae. Although the mass oviposition cage has not entirely supplanted the small oviposition cage it has a definite place in the propagation methods especially when large numbers of ovipositing females are available.

The most important contributions, however, in the development of suitable methods for large-scale breeding are those designed for the treatment of parasitized larvae and parasite puparia. The parasitized larvae, after being removed from the oviposition cages, are placed directly into the cells of the screen-bottomed tray shown in Figure 5 and are then incubated. As previously mentioned, the incubation trays are used successfully in propagation in two ways. The first of these, however, is considered to be the more satisfactory since the handling of the puparia is avoided. The incubation trays containing the parasitized larvae are placed directly in the combined incubation and emergence cage shown in Figure 4. The cage can be sealed completely once the trays are placed in their proper sections. The mature parasite larvae emerge from the

host remains and crawl through the wire-screening, dropping to the floor of each section below. Pupation occurs and the puparia are usually found adhering to the floor. With continued incubation, emergence of the adults takes place and the flies escape through the series of exit holes, being attracted to the illuminated centre compartment. This compartment affords adequate space for large numbers of emerging flies which normally collect on the walls to expand their wings, rest and feed for the first time. The flies are removed from the centre compartment by means of a glass sucker-tube inserted through one of the openings in the transparent cage-front.

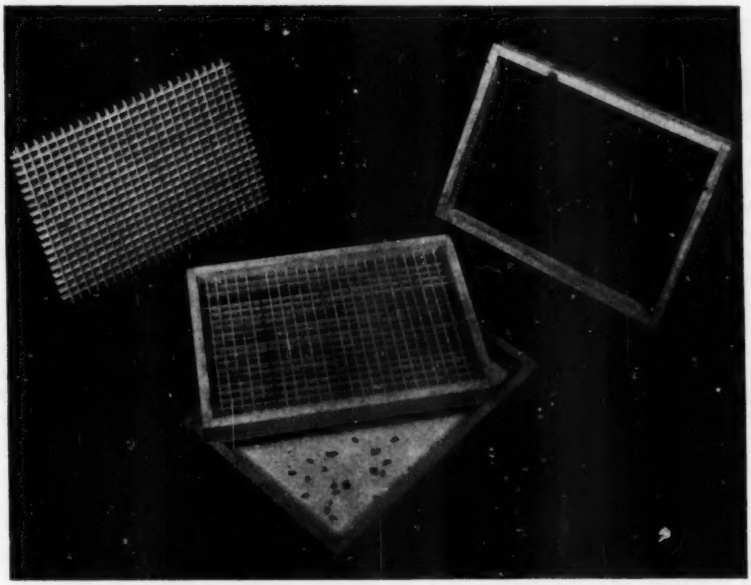

Figure 5. Incubation tray with grid removed to show screen bottom and two-tray unit.

The second method, or alternative treatment of the parasitized larvae, requires more attention. An incubation unit is shown in the centre foreground of Figure 5. The parasite larvae crawl through the screen floor of the upper tray and drop into the tray beneath. The lower tray is equipped with a removable paper mat upon which the larvae pupate. The trays are examined daily and the mats removed. Puparial cases which do not normally adhere to the paper are fastened there with a 20 per cent solution of gum acacia, care being taken to prevent the sealing of the respiratory opening or cephalic end of the puparial cases. The puparia should not be placed too closely together since normal emergence of some may be prevented. The paper mats are then suspended from the sides and top of cages similar in size and construction to the centre compartment of the large cage. Small numbers of puparia can be handled similarly in smaller cages.

The presence of food in the emergence cages at all times is of considerable importance in the breeding of healthy vigorous flies. In addition to the daily replacement of the honey-soaked cotton on the food-board, cubes of sugar are suspended on bent pins from the sides and back of each cage, and flies can often be observed feeding on the sugar. It is advisable to have the emergence

cages large enough to prevent crowding. Another practice of major consideration is that of spraying the cages with a fine mist of water twice daily. Temperature and humidity must be maintained at the optimum levels at all times.

DISCUSSION

Techniques and new-type equipment designed to increase production of *Sturmia* sp. have been given a thorough trial during the past two seasons. They have proven satisfactory from the standpoint of both production and utilization of available space. The use of the cage for obtaining mass parasitism has made it possible for one attendant to manage 200 or more ovipositing adults whereas, by former methods, only 75 females could be handled satisfactorily.

The use of the screen-bottom trays has taken the place of the time-consuming work formerly necessary in the plugging and unplugging of vials. The removal of the puparia from the vials and the frequent injury caused by attendants was often responsible for the invasion of the parasites by disease organisms and their subsequent death. Data secured from the past two seasons' propagation have shown an increase in the survival of the parasites of some 20 per cent. The compactness of the cages has made it possible to breed large numbers of parasites in a relatively small space. The production during the past two seasons has amounted to 150,000 parasites for release. With the methods formerly employed, the number of parasites propagated for release during a season never exceeded 20,000.

The introduction of the food board and food cartridge has proven of great value in maintaining sanitary conditions in the cage. Liquid foods, when in contact with the wooden parts of the cage, often promote the growth of such organisms as yeasts and moulds. Certain insect species have been observed to react violently after eating this contaminated food. The food cartridge, if handled properly, avoids the possibility of spilled liquids and causes no disturbance to the insects when removed.

SUMMARY

Experiments were conducted in an attempt to improve methods of large-scale breeding of insect parasites for release.

The life-history and earlier methods of propagation of *Sturmia* sp. are outlined briefly.

The cages designed for mass parasitism, incubation, and emergence are described in detail as well as an improved method for feeding the parasites. The details of construction are supplemented with drawings and photographs of cages now in use.

The methods of propagating parasites by the use of the new-type cages are described and their value under laboratory conditions shown. Survival has been increased 20 per cent and approximately 150,000 parasites have been reared for release during the past two seasons without additional personnel.

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GUELPH PRINTING SERVICE
Mailed Wednesday, September 17, 1947.